



Advisory Circular

U.S. Department
of Transportation

**Federal Aviation
Administration**

Subject: GUIDELINES FOR DESIGN APPROVAL
OF AIRCRAFT DATA COMMUNICATIONS SYSTEMS

Date: 8/16/99

Initiated by: AIR- 100

AC No: 20- 140

Change:

1. PURPOSE. This advisory circular (AC) is issued to support the introduction of data communications applications for air traffic services (ATS). Ultimately, the International Civil Aviation Organization (ICAO) will use data communications applications to implement the communication, navigation, and surveillance (CNS) concepts that describe the future air navigation system (FANS). This AC provides guidelines for design approval of aircraft data communications systems and applications primarily used for air traffic services (ATS). Like all advisory material, this AC is not, in itself, mandatory and does not constitute a regulation. It is issued to provide guidelines and to outline a method of compliance with airworthiness standards contained in the Title 14, Code of Federal Regulations (CFR), subchapter C. This AC will also ensure standardization among the Aircraft Certification Offices (ACO) in their assessment of aircraft data communications systems and applications for design approval. This AC was developed in consideration of the ICAO standards and recommended practices (SARPs) and in cooperation with foreign civil air authorities (FCAA). A comment form is included in appendix 5 of this AC to allow ACO's and other users to offer comments during the use of this AC.

2. BACKGROUND. Aircraft operators have been using very high frequency (VHF) based aircraft communications addressing and reporting system (ACARS) data communications systems for aircraft operational control (AOC) and aeronautical administrative control (AAC) for more than a decade. Recently, the use of these data communications systems have been approved for limited ATS, such as pre-departure clearance (PDC) at domestic airports, and their use in air traffic management (ATM) operations is continuing to expand. As a supplement to HF voice radio communications, satellite-based data communications, in conjunction with the ACARS network, are being used in oceanic airspace to report aircraft position. Based on this experience, the industry believes that the satellite subnetwork, data communications system, and applications are essential to the success of implementing the ICAO FANS concepts associated with CNS. Aircraft operators are now seeking approval of satellite-based data communications to improve two-way communications and surveillance for ATM in oceanic and remote airspace.

a. Current data communications systems and applications installed on aircraft have been approved as non-essential equipment and shown to not interfere with more critical functions on the aircraft. That is, the applicants have substantiated that the effects of failures and design errors would contribute to only minor failure conditions for the data communications applications. However, when data communications systems are used for ATS applications, failures and design errors of the data communications system and applications may contribute to failure conditions whose classification is more severe than minor.

b. To adequately assess the effects of failures and design errors, this AC describes a means. using the safety assessment. to identify safety requirements for the operational environment in which the aircraft data communications system and applications will operate and the requirements for interoperability with the air/ground subnetwork. ground data communications system. and ground applications. Although these safety and interoperability requirements will be defined to support the design approval of the aircraft data communications system and applications, they will be used to facilitate the operational authorization to use the data communications applications as they evolve.

3. RELATED INFORMATION. Appendix 1 provides 3 list of sections from Title 14 Code of Federal Regulations (CFR) parts 23, 25, 27, and 29 that should be considered when determining the certification basis for approving aircraft data communications systems and the applications. This appendix also provides references to advisory circulars (AC), technical standard orders (TSO), and industry documents that may be useful in determining the means for showing that the aircraft data communications system and the applications comply with the certification basis. These references are applicable to the means of compliance described herein only when specifically identified in the body of this AC or as negotiated during the certification planning process described in paragraph 6 of this AC. The appendix also lists industry activities, which are producing documents related to data communications systems, the applications, and their use.

4. SCOPE. This AC provides guidelines for design approval of aircraft systems that provide the data communications function and applications on the aircraft. The data communications function and applications on the aircraft communicate digital data with the ground computer systems managed by air traffic, a service provider, or an aircraft operator. Digital data are exchanged between the aircraft and the ground systems and are used to display or print information to the flightcrew or controller or directly interface with other computer applications, such as flight planning and navigation, on the aircraft and surveillance on the ground. The aircraft systems that provide this capability will be referred to throughout this AC as aircraft data communications systems and applications. This AC considers the following:

a. Evolutionary development. The guidelines contained in this AC are applicable to all aircraft data communications systems and applications, even those that may not be compatible with the ICAO aeronautical telecommunication network (ATN). Therefore, this AC provides for the data communications technology to evolve within the national airspace system (NAS) and international airspace during operational service without compromising safety, while at the same time it provides the flexibility to migrate to ATN-compatible data communications systems.

b. Data communications applications. Guidelines provide for the addition and modification of data communications applications and minimize the evaluation of the data communications system. Data communications systems and applications that use protected navigation frequencies, such as 3s for delivery of differential global positioning system (DGPS) information, are beyond the scope of this AC and will be addressed in documents providing guidance for design approval of navigation functions. Examples of data communications applications are controller-pilot data link communications (CPDLC) for pilot-controller communication, automatic dependent surveillance (ADS), pre-departure clearance (PDC), oceanic clearance, automatic terminal information service (ATIS), weather services, ATS facilities notification (AFN) for the ACARS, and context management for ATN.

c. Data communications system subnetworks. Guidelines provide for the data communications system to use 3 variety of air/ground subnetworks, including satellite, very high frequency (VHF) radio, high frequency (HF) radio, Mode S, and gatelink.

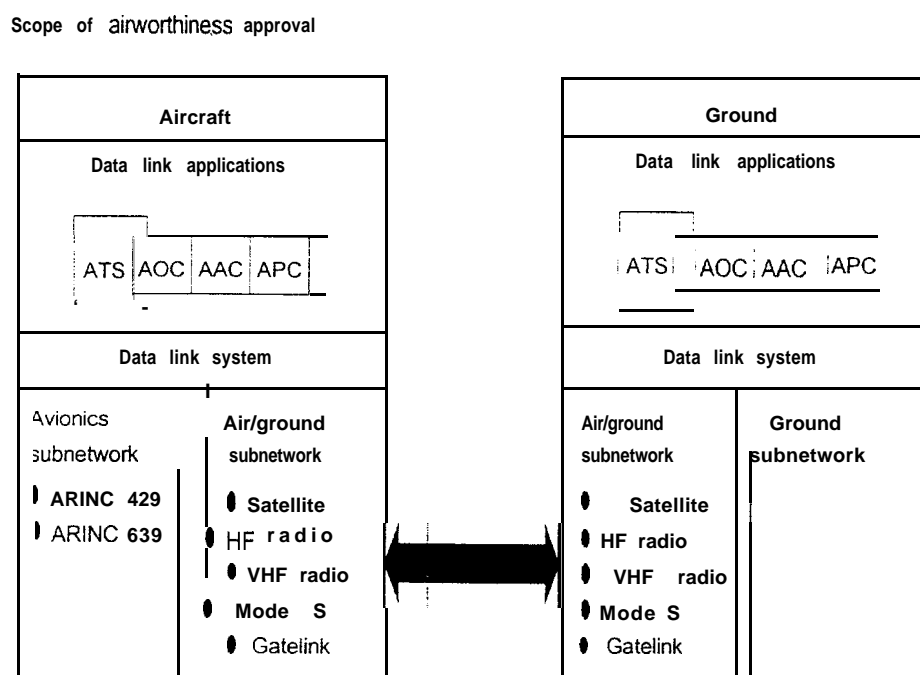
d. Institutional considerations. Different parts of the data communications system and applications are controlled by different organizations. For example, within the FAA, the Aircraft Certification Service is responsible for design approval, whereas the Flight Standards Service is responsible for operational authorization. In some cases, a foreign civil air authority (FCAA) will be responsible for operational authorization. Other organizations, some non-Federal, are responsible for commissioning the air/ground subnetwork, ground data communications system, and ground applications.

e. International implications. The Aircraft Certification Service is coordinating these guidelines for design approval of aircraft data communications systems and applications with FCAA. We intend to harmonize the airworthiness criteria contained within this AC.

NOTE: This AC discusses the operational concepts of data communications applications and the NAS only to describe the relationship of the design approval of aircraft data communications systems and applications with the commissioning of ATS facilities and operational authorizations. This information should not be misinterpreted as guidance for obtaining an operational authorization to use ATS data communications applications or for commissioning ground and space segments of the data communications system and applications. This AC only provides guidance for obtaining design approval of the aircraft data communications system and applications.

5. OVERVIEW OF THE DATA COMMUNICATIONS SYSTEM AND APPLICATIONS. This paragraph provides an overview of the data communications system and applications as shown in figure 1.

Figure 1: OVERVIEW OF THE DATA COMMUNICATIONS SYSTEM AND APPLICATIONS



c. Interoperability. The interoperability requirements define the operational environment which ensures the aircraft data communications applications, the data communications system, and the ground applications are compatible. For the aircraft systems, the validation and verification activities performed during system development need to validate the interoperability requirements allocated to the aircraft systems and ensure that the aircraft implementation satisfies its requirements.

d. Validation of safety and interoperability. The applicant seeking design approval needs to identify the safety and interoperability requirements because the applicant cannot ensure that the operational environment satisfies its requirements, which is beyond the scope of the design approval. The Aircraft Certification Service will coordinate the safety and interoperability requirements provided by the applicant with the appropriate FAA organizations to validate the requirements allocated to the operational environment and to ensure that the operational environment satisfies its requirements.

e. Certification plan. When planning for design approval, the applicant should provide the following:

(1) Description. Describe the aircraft data communications system, the applications, and their interface with other systems and functions on the aircraft. Describe the operation (e.g., human/machine interface) and the flight deck arrangement. See also the guidelines contained in paragraph 9 of this AC.

(2) Safety assessment. Define the safety assessment activities and their interrelationships with other activities within the design approval process. See also the guidelines contained in paragraph 7 of this AC.

(3) Safety and interoperability requirements. Define the means to identify safety requirements for the aircraft systems and for the operational environment and the interoperability requirements. In addition to the following, see also the guidelines contained in paragraph 8 of this AC.

(a) To facilitate the coordination process within the FAA, the applicant is encouraged to submit the safety and interoperability requirements in electronic media format acceptable to the ACO. The ACO will need to coordinate the safety and interoperability requirements with the Aircraft Engineering Division of the Aircraft Certification Service prior to design approval of the aircraft data communications system and the applications. The Aircraft Engineering Division will coordinate with other organizations responsible for approval of different parts of the data communications system, the applications, and the authorization to use those applications, as necessary, to substantiate the validity of safety requirements and to ensure the feasibility of interoperability requirements.

(b) The users of the data communications applications will use the safety and interoperability requirements to facilitate operational authorization. The safety and interoperability requirements will also determine the level necessary to substantiate subsequent changes to the air/ground subnetwork, ground data communications system, and ground applications, including networks and applications provided by non-FAA service providers and other certification authorities. Additional substantiation may be necessary to support operational authorization to ensure the design approval of the aircraft data communications system and the applications is not compromised.

(4) Validation of requirements. Describe the means for validating the requirements for the aircraft data communications system and the applications and the safety and interoperability requirements for the operational environment.

(5) Design assurance for aircraft systems. Describe the means for ensuring that the implementations provided by the aircraft systems satisfy the requirements for the aircraft data communications system and the applications.

(a) Development processes. Define the development processes, including the supporting processes, how the applicant will coordinate with the certification authority throughout certification, and the interrelationships among processes.

(b) System development environment. Define the system development environment, including the methods and tools to be used during the system design, development, and safety assessment processes. If tools are used to replace verification and validation activities, define the means by which the tools will be qualified.

(c) Standards and guidelines. Specify international, national, corporate, or project standards that will be used to support the selection of valid functional requirements and verifiable design implementations.

(d) Consideration of design errors. Define the methods used for considering errors in the aircraft system design (for example, architectural means, safety directed life cycle, systematic approach to systems development, exhaustive input testing, service experience). Also, define the acceptance criteria for each of the techniques used. Define the means that will protect the more critical functions from the malfunction or failure of less critical functions.

(e) Consideration of random failures. Define the methods used to allocate the reliability requirements to the various parts of the aircraft systems. The methods used for meeting those requirements should also be defined (for example, probability analysis of failure rates).

(f) User-modifiable, option-selectable functions. If the aircraft data communications system or its applications are designed to be modified (e.g., user-selectable options or partitioned user-modifiable software) without a re-evaluation for airworthiness, then define the means (for example, processes, design features, environment, tools, certification data) by which the safety requirements, as determined by the safety assessment, will be ensured throughout the service life of the system and means by which the configuration of these features will be managed.

(g) Certification data. Define the means for providing evidence showing that the aircraft data communications system and applications comply with airworthiness requirements. Describe how certification data will be packaged, in what form, and how certification data are made available to the certification authority. For example, the certification plan may provide an overview of the processes and refer to other documents that define the processes.

(h) Process assurance. Describe the involvement of the designated engineering representative (DER) and the FAA certification engineer that is necessary throughout the certification process to ensure that the certification plan complies with the guidelines contained herein and that the actual processes comply with the certification plan or its references.

(6) Flight and ground tests and flight manual provisions. Define the objectives and acceptance criteria for flight and ground tests. The flight and ground tests should include tests to validate the aircraft data communications system and applications in the context of the safety and interoperability requirements and to check for adverse effects on other aircraft systems and functions.

(5) When the aircraft data communications application is sharing a display with other aircraft functions, the aircraft data communications applications may override the display of the time shared function provided the flightcrew can return the display to the shared function. ATS aircraft data communications applications should not share a display with an aircraft function that is of equal or higher Importance than the aircraft data communications application.

m. Flight deck print capability. A flight deck printer may be used as an acceptable means of providing storage of data communications messages received or sent during the current flight. If installed on the flight deck and used for storing data communications messages, it should have the following characteristics:

(1) The printer should be located in a position which does not require either of the pilots to leave his seat to access information and should be able to be serviced without lengthy distraction from other pilot tasks.

(2) A means should be provided for the flightcrew to selectively print any displayed or stored message.

(3) The printer should be capable of printing any data communications message selected by the flightcrew.

(4) The printer quality should be equivalent to at least an ARINC 740 printer.

(5) The printer should accommodate the maximum length message.

(6) The paper capacity should preclude the need for frequent in-flight servicing.

10. GROUND AND FLIGHT TEST EVALUATION. The ground and flight tests for certification should evaluate the aircraft data communications system and applications in the context of the safety and interoperability requirements. Ground and flight tests should consider the following criteria:

a. Self test. Evaluate any self test features against the requirements specified by the manufacturer.

b. Performance of data communications system and applications. Evaluate the functional operation of the data communications applications and their feasibility for operational use. Evaluate message delivery times for uplink and downlink, long messages that require paging, receipt and acknowledgment of multiple uplink messages sent simultaneously from more than one source, and message queue capacities to the performance criteria specified in the safety and interoperability requirements.

c. Human/machine interface. Evaluate the data communications system installation for satisfactory identification, accessibility, and visibility. Evaluate the flight deck arrangement and operation of controls, displays, printers, circuit breakers, annunciators, alerts, and any placards of the data communications system and applications in day, night, and dusk conditions. Evaluate the human/machine interface to ensure that it is consistent with the flightcrew interface and flight deck design of the particular aircraft and the guidelines provided in this AC. Insert failure modes of the data communications system and the applications to evaluate aural and visual annunciations.

d. Operational considerations. Evaluate loss of the data communications system when the primary communication system is out of range (e.g., use of data communications applications in rotorcraft operating in the Gulf of Mexico and the primary means of communication is VHF voice radio). Evaluate

operational procedures, such as a procedure to check message integrity, which may be required to substantiate the classification of effects of failure conditions. Determine that the system provides a means of operation with acceptable effects on crew workload and without excessive reliance on memory for correct procedural steps.

e. System Integration. Evaluate the integration of the data communications system and applications with other systems, such as the flight management system (FMS), to ensure that the integration presents no hazard to existing systems on the aircraft and the data communications system and applications do not interfere with other systems. Evaluate the effects of electromagnetic interference to ensure the data communications system is compatible with existing systems on the aircraft.

11. AIRPLANE/ROTORCRAFT FLIGHT MANUAL (A/RFM) (SUPPLEMENT) WORDING. The A/RFM or A/RFM supplement should provide a description of all normal and submodes of system operation including what actions are expected by the flightcrew for each case. A reduction in the material addressed by the A/RFM or A/RFM supplement may be permitted for those cases where information is included in other related references, such as a flightcrew operating manual that is used by the operator as the basis for flightcrew qualification.

a. Operating Limitations. Operating limitations should be used to control the use of data link applications that are intended for evaluation in operational service or if an operating limitation would provide an alternative to satisfying the criteria contained in this AC. For example, although the printer is optional, a limitation that requires a printer would be appropriate for implementations where the flightcrew must rely solely on the printer to retrieve messages. Operating limitations are not necessary provided the data link system and applications have been shown to satisfactorily operate in the context of the safety and interoperability requirements. For example, operational procedures performed by the flightcrew, service provider, and air traffic controller may be used to substantiate use of the data link system in oceanic and remote areas as a means to compensate for the lack of integrity in the data link system. Those aspects of the procedures that provide the substantiation for such use in the safety assessment would be identified as safety requirements for the operational environment.

b. Operating Procedures. The normal and non-normal operating procedures of the A/RFM or A/RFM supplement should be consistent with and refer to the safety and interoperability requirements that were used to demonstrate the system. For example, "The FAA has approved the data link system and applications to the criteria contained in AC 20-140, dated July 16, 1999. This approval was based on the safety and interoperability requirements contained in (applicant's) (document title) (revision and/or date). This design approval does not constitute operational authorization."

12. CERTIFICATION SUMMARY. The applicant should submit a certification summary to provide the results of the activities proposed in the certification plan. Any deviation to the certification plan should be described in the certification summary together with rationale to substantiate the deviation. In addition to addressing each of the content items in the certification plan, the certification summary should include:

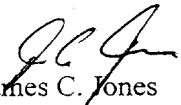
a. Statement of compliance. A statement indicating that the aircraft data communications system and applications in the context of the safety and interoperability requirements complies with airworthiness requirements

b. Open problem reports. A summary of the open problem reports and their impact on safety, airworthiness, operational requirements and any ICAO Document 9705 problem description reports implemented and/or submitted.

13. CERTIFICATION DATA. In addition to the certification data that may be necessary to satisfy the criteria contained in other Acs referenced in this AC or as negotiated in the certification plan, the applicant should provide the certification data contained in table 2. The presentation of the data items listed in the table is not intended to imply packaging of the data or form.

Table 2. CERTIFICATION DATA

Item #	Description of Data Item	Reference
1	Certification Plan	Paragraph 6
2	Safety Assessment	Paragraph 7 Appendix 3
3	Safety and interoperability	Paragraph 8 Appendix 4
4	Aircraft system requirements	Paragraph 9
5	Ground and flight test plan and procedures	Paragraph 10
6	Airplane flight manual wording	Paragraph 11
7	Certification summary	Paragraph 12


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APPENDIX 1. RELATED INFORMATION

This appendix provides a list of sections of 14 CFR applicable to determine the certification basis for approving aircraft data communications systems and the applications. This appendix also provides references to advisory circulars (AC), technical standard orders (TSO), and industry documents that may be useful in determining the means for showing that the aircraft data communications system and the applications comply with the certification basis. These references are applicable to the means of compliance described herein only when specifically identified in the body of this AC or as negotiated during the certification planning process described in paragraph 6 of this AC. The appendix also lists industry activities, which are producing documents related to data communications systems, the applications, and their use.

1. Title 14 Code of Federal Regulations (CFR). The following sections of 14 CFR are applicable to the certification aspects of data communications systems and applications:

Description	14 CFR part 23	14 CFR part 25	14 CFR part 27	14 CFR part 29
Subpart C---Structure (Strength Requirements)				
<i>General</i>				
Loads.	§ 23.301	§ 25.301	§ 27.301	§ 29.301
Factor of safety.	§ 23.303	§ 25.303	§ 27.303	§ 29.303
Strength and deformation.	§ 23.305	§ 25.305	§ 27.305	§ 29.305
<i>Emergency Landing Conditions</i>				
General.	§ 23.561	§ 25.561	§ 27.561	§ 29.561
Subpart D---Design and Construction				
General.	§ 23.601	§ 25.601	§ 27.601	§ 29.601
Materials (and workmanship).	§ 23.603	§ 25.603	§ 27.603	§ 29.603
Protection of structure.	§ 23.609	§ 25.609	§ 27.609	§ 29.609
Subpart F-Equipment				
<i>General</i>				
Function and installation.	§ 23.1301	§ 25.1301	§ 27.1301	§ 29.1301
Flight and navigation instruments.	§ 23.1303	§ 25.1303	§ 27.1303	§ 29.1303
Miscellaneous equipment.	§ 23.1307	§ 25.1307	§ 27.1307	§ 29.1307
Equipment, systems, and installations.	§ 23.1309	§ 25.1309	§ 27.1309	§ 29.1309
<i>Instruments: Installation</i>				
Electronic display instrument systems	§ 23.1311	N/A	N/A	N/A
Arrangement and visibility.	§ 23.1321	§ 25.1321	§ 27.1321	§ 29.1321
Warning, caution, and advisory lights.	§ 23.1322	§ 25.1322	§ 27.1322	§ 29.1322
Instruments using a power supply.	§ 23.1331	§ 25.1331	N/A	§ 29.1331
Instrument systems.	N/A	§ 25.1333	N/A	§ 29.1333

APPENDIX 1. RELATED INFORMATION (Continued)

Description	14 CFR part 23	14 CFR part 25	14 CFR part 27	14 CFR part 29
<i>Electrical Systems and Equipment</i>				
General.	§ 23.1351	§ 25.1351	§ 27.1351	§ 29.1351
Electrical equipment and installations. (Storage battery design and installations.)	§ 23.1353	§ 25.1353	§ 27.1353	§ 29.1353
Distribution system.	N/A	§ 25.1355	N/A	§ 29.1355
Circuit protective devices.	§ 23.1357	§ 25.1357	§ 27.1357	§ 29.1357
<i>Lights</i>				
Instrument lights.	§ 23.1381	§ 25.1381	§ 27.1381	§ 29.1381
<i>Miscellaneous Equipment</i>	+	+	+	+
Electronic equipment.	§ 23.1431	§ 25.1431	N/A	§ 29.1431
Cockpit Voice Recorders	§ 23.1457	§ 25.1457	§ 27.1457	§ 29.1459
Flight recorders.	§ 23.1459	§ 25.1459	§ 27.1459	§ 29.1459
Subpart G-Operating Limitations and Information				
<i>Operating Limitations</i>				
Instructions for Continued Airworthiness	§ 23.1529	§ 25.1529	§ 27.1529	§ 29.1529
<i>Markings and Placards</i>				
General.	§ 23.1541	§ 25.1541	§ 27.1541	§ 29.1541
<i>Airplane/Rotorcraft Flight Manual</i>				
General.	§ 23.1581	§ 25.1581	§ 27.1581	§ 29.1581
Operating limitations	§ 23.1583	§ 25.1583	§ 27.1583	§ 29.1583
Operating procedures.	§ 23.1585	§ 25.1585	§ 27.1585	§ 29.1585

2. Advisory Circulars (AC). The following AC's may provide additional information to assist in the approval of data communications systems for certification:

- a. AC 20-1 15B, RTCA, Inc., Document RTCA/D0-178B, dated January 11, 1993.
- b. AC 23.1309-1A, Equipment, Systems, and Installations in Part 23 Airplanes, dated June 3, 1992, and Change No. 1, dated August 5, 1992.
- c. AC 23.13 1 1-I, Installation of Electronic Display Instrument Systems in Part 23 Airplanes, dated June 11, 1993.
- d. AC 25.1309-1A, System Design and Analysis, dated June 21, 1988.
- e. AC 25-1 1, Transport Category Airplane Electronic Display Systems, dated July 16, 1987.

APPENDIX 1. *RELATED INFORMATION* (Continued)

f. AC 27-1, Certification of Normal Category Rotorcraft, dated August 8, 1985. including Change 1, dated September 16, 1987 and Change 2, dated April 24, 1989.

g. AC 29-2A, Certification of Transport Category Rotorcraft, dated September 16, 1987, including Change 1, dated April 24, 1989.

3. FAA Technical Standard Orders (TSOs). The following documents are available for equipment approvals:

a. TSO-C3 1 d, High Frequency (HF) Radio Communications Transmitting Equipment Operating Within the Radio Frequency Range 1 S-30 Megahertz, dated April 30, 1984.

b. TSO-C32d, High Frequency (HF) Radio Communications Receiving Equipment Operating Within the Radio Frequency Range 1.5-30 Megahertz, dated April 30, 1984.

c. TSO-C37d, VHF Radio Communications Transmitting Equipment Operating Within the Radio Frequency Range 117.975 to 137.000 Megahertz, dated September 23, 1992.

d. TSO-C38d, VHF Radio Communications Receiving Equipment Operating Within the Radio Frequency Range 117.975 to 137.000 Megahertz, dated September 23, 1992.

e. TSO-C112, Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment, dated February 5, 1986.

f. TSO-C113, Multi-Purpose Electronic Displays, dated October 27, 1986.

4. RTCA, Inc. (RTCA) documents. The following documents are available from RTCA, Inc.:
1140 Connecticut Avenue, NW, Suite 1020. Washington, D.C. 200364001:

a. RTCA DO- 160D, Environmental Conditions and Test Procedures for Airborne Equipment, dated July 29, 1997.

b. RTCA DO-1 78B, Software Considerations in Airborne Systems and Equipment Certifications, dated December 1, 1992.

c. RTCA DO- 18 1 A, Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment, dated January 14, 1992.

d. RTCA DO-205, Design Guidelines and Recommended Standards to Support Open System Interconnections for Aeronautical Mobile Digital Communications, Part 1 - Internetworking, dated March 21, 1990.

e. RTCA DO-210D, Minimum Operational Performance Standards (MOPS) for Aeronautical Mobile Satellite Services, dated January 16, 1996.

f. RTCA DO-2 12, Minimum Operational Performance Standards (MOPS) for Airborne Automatic Dependent Surveillance (ADS) Equipment, dated October 26, 1992.

APPENDIX 1. RELATED INFORMATION (Continued)

- g. RTCA DO-215, Guidance on AMSS End-to-End System Performance, dated April 13, 1993.
 - h. RTCA DO-218, Minimum Operational Performance Standards for Mode S Aircraft Data Link Processor, dated August 27, 1993.
 - i. RTCA DO-219, Minimum Operational Performance Standards (MOPS) for Two-Way Data Link (TWDL) Communications, dated August 27, 1993.
 - j. RTCA DO-240, Minimum Operational Performance Standards (MOPS) for Aeronautical Telecommunication Network (ATN) Avionics, dated July 29, 1997.
5. Society of Automotive Engineers, Inc. (SAE) documents. The following documents are available from the Society of Automotive Engineers, Inc. (SAE), 400 Commonwealth Drive, Warrendale, PA 15096:
- a. SAE Aerospace Recommended Practice (ARP) 926A, Fault/Failure Analysis Procedure.
 - b. SAE ARP 1834, Fault/Failure Analysis Guidelines for Digital Equipment.
 - c. SAE ARP 4101, Flight Deck Layout and Facilities.
 - d. SAE ARP 4102, Flight Deck Panels, Controls and Displays.
 - e. SAE ARP 4791, Human Engineering Recommendations for Data Link Systems.
6. International Civil Aviation Organization (ICAO) documents. The following documents are available from International Civil Aviation Organization, 1000 Sherbrooke Street W, Suite 400, Montreal, Quebec, Canada H3A2R2.
- a. ICAO ANNEX 10 to the Convention of International Civil Aviation; Volume II.
 - b. ICAO ANNEX 10 to the Convention on International Civil Aviation; Volume III; Part I - Digital Data Communication Systems, Chapter 3, Aeronautical Telecommunication Network.
 - c. ICAO Circular 226-AN/135, Automatic Dependent Surveillance.
 - d. ICAO Doc 9524, FANS/4, Special Committee on Future Air Navigation Systems.
 - e. ICAO Doc 9578-AN/935, Second Edition, ATN Manual, dated November 19, 1993.
 - f. ICAO Doc 9705-AN/956, Manual of Technical Provisions for the Aeronautical Telecommunication Network.
7. Aeronautical Radio, Inc. (ARINC) documents. These documents are available from Aeronautical Radio, Inc., 2551 Riva Road, Annapolis, Maryland 21401-7465.
- a. ARINC Specification 429-14, Mark 33 Digital Information Transfer System (DTIS), dated March 1993.

APPENDIX 1. RELATED INFORMATION (Continued)

- b. ARINC Specification 618, Air-Ground Character Oriented Protocol Specification, dated January 1993.
 - c. ARINC Specification 619, ACARS Protocols for Avionic End Systems, dated December 1993.
 - d. ARINC Specification 620-1, Data Link Ground System Standard and Interface Specification, dated January 1994.
 - e. ARINC Specification 623-1, ATS Data Link Applications Over ACARS Air-Ground Network, dated November 1993.
 - f. ARINC Specification 631-1, Aviation Packet Communications Functional Description, dated January 1993.
 - g. ARINC Characteristic 702-4, Flight Management Computer, dated January 1993; and Supplement 5, dated February 1992.
 - h. ARINC Characteristic 724B-2, Aircraft Communications Addressing and Reporting System, dated November 1993.
 - i. ARINC Characteristic 740-1, Multiple-Input Cockpit Printer, dated June 1988.
 - j. ARINC Characteristic 741, Aviation Satellite Communication System, Part 1-5, dated March 1994; Part 2, dated July 1992; Part 2, Supplement 2, dated February 1994; Part 3, dated January 1994; and Part 4, dated May 1992.
 - k. ARINC Characteristic 745-2, Automatic Dependent Surveillance, dated June 1993.
 - l. ARINC Characteristic 751, Gate-Aircraft Terminal Environment Link (Gatelink) - Aircraft Side, dated January 1994.
 - m. ARINC Characteristic 758, Communications Management Unit.
8. Other related material.
- a. International Organization for Standardization (ISO) Standards; ISO 7498 - Basic Reference Model. This document can be obtained from the American National Standards Institute (ANSI), 11 West 42nd Street, New York, NY 10036.
 - b. International Telecommunication Union (ITU) Radio Regulations. This document may be obtained from the ITU in Geneva, Switzerland.
 - c. Air Transport Association of America (ATA) Information Transfer Subcommittee, Human Factors Requirements for Data Link, dated June 18, 1992.
9. Current industry and FAA activities. Industry and FAA are currently working technical issues and developing documents for recognition by the FAA in advisory material.

APPENDIX 1. RELATED INFORMATION (Continued)

The draft versions of these documents contain material relevant to data communications systems and applications. Relevant material has been included in the body of this AC to allow for timely implementation of data communications systems and the applications and to minimize the implications of applying these documents to follow-on design approvals.

The FAA intends to refer to these documents by reference only in future advisory material pertaining to the design approval of data communications systems and applications. This paragraph includes a summary of current industry activities.

a. Flight Standards Service is planning to issue two documents to implement recommendations of the C/SOIT. Draft AC 120.COM will provide criteria for operational authorization.

b. FAA/Joint Aviation Authority (JAA) 25.1309 Systems Design and Analysis Harmonization Working Group/ARAC Working Group is revising § 25.1309 of 14 CFR, the Joint Airworthiness Requirements (JAR) and associated AC 25.1309-1A and Advisory Material Joint (AMJ) 25.1309.

c. RTCA SC- 189 and EUROCAE WG53 are developing guidelines for developing operational context, safety assessment, and performance requirements methodology for airborne data communications.

d. RTCA SC-1 80 and EUROCAE WG 46 are developing guidelines for airborne systems and equipment to address increased complexity in hardware designs resulting from micro-circuit technology. RTCA and EUROCAE are planning to develop design assurance techniques that will consider errors in hardware designs for avionics systems.

e. SAE Systems Integration Requirements Task Group (SIRT) is developing guidelines for systems development and supporting processes, which include the safety assessment, requirements validation, design verification, configuration management, process assurance, and certification.

f. SAE S-1 8 is developing a handbook which provides tools and detailed information on safety assessments.

APPENDIX 2. DEFINITIONS AND ACRONYMS

This appendix contains definitions of terms and acronyms used throughout this AC.

1. Definitions.

Aeronautical administrative communication (AAC). AAC applications are non-safety related services which include cabin services, seat assignments, passenger travel arrangements, and baggage tracing.

Aeronautical operational control (AOC). AOC applications provide safety related services for routine operational control which includes weather information, flight plans, company operational communications, and connecting flight information; emergency which includes in-flight emergency communications and special medical requests; and aircraft maintenance which includes the delivery of engine, avionics, and airframe information to expedite maintenance services.

Aeronautical public correspondence (APC). APC applications are non-safety related services which include voice (e.g., telephone) and data (e.g., facsimile and computer) communication services that passengers and crew can use to connect with ground based network subscribers worldwide.

Aircraft -level function. An aircraft-level function is defined by the functional requirements established from basic aircraft performance and operational requirements. For example, aircraft data communications applications satisfy operational requirements. The aircraft data communications system is a requirement that is derived from the aircraft data communications applications requirements and does not perform an aircraft-level function by itself.

Air traffic management (ATM). ATM applications include pilot/controller communications which include the operational communications between pilots and controllers, advanced ATM which includes air/ground digital data transfers supporting more efficient operations, and traffic flow management (TFM).

Air traffic services (ATS). ATS applications are divided into four categories: Air Traffic Management, Flight Information, Surveillance, and Navigation. The definitions of these categories are contained in this appendix.

Design approval. Design approval describes the process that an applicant and the certification authority use to substantiate that the aircraft data communications system and applications comply with airworthiness requirements appropriate for the certification authority (e.g., 14 CFR parts 21 through 29 if the certification authority is the Aircraft Certification Service within the FAA).

Availability. Although this AC does not use the term “availability” other than in its normal usage, it is defined here because it is used within the aviation community. Availability criteria refer to the criteria associated with loss of the function, system, and equipment. For example, the effects of indefinite loss of an ATS data communications application is classified during the safety assessment. Depending on design constraints and assumptions made about the operational environment, loss of an ATS data communications application for more than a specified period of time (e.g., 30 minutes) may be the failure condition considered.

APPENDIX 2. DEFINITIONS AND ACRONYMS (Continued)

Data communications applications. Data communications applications comprises the software and hardware necessary to perform a task that can be used to provide an operational benefit. Data communications applications can reside on the aircraft as an aircraft application or at an air traffic, service provider, or operator facility as a ground application.

Data link system. The data communications system comprises the aircraft data communications system, one or more of the air/ground subnetworks, and the ground data communications system. The data communications system supports data communications applications.

Flight information services (FIS). FIS applications include real-time advisories and warnings which have a direct effect on flight safety; flight information planning services which are used in strategic flight planning; and collection of aircraft observations which support wider dissemination of pilot and instrument observations of current atmospheric conditions.

Ground/space system commissioning. Ground/space system commissioning describes the process(es) that service providers and certification authorities use to commission an air/ground subnetwork, ground data communications system, or ground application for operational service in accordance with established requirements (e.g., FAA Orders and Directives, 14 CFR parts 170 through 191, international and federal telecommunication regulations, and other requirements, if the certification authority comprises the air traffic services, the airways facilities services, system development services, and other participating services of the FAA).

Integrity. Integrity describes the characteristics of a function indicating a level of confidence that the function will perform as intended under all operating scenarios. For example, validating the safety requirements for the system design and ensuring that the implementation satisfies those requirements provide integrity for the system.

Interoperability requirements. Interoperability requirements define the requirements that provide the basis for ensuring compatibility among the various components comprising the distributed data applications and the communications infrastructure in the aircraft and external to the aircraft.

Navigation communication services. Navigation communication services include the delivery of DGPS data and other supplemental information and for the delivery of information related to observed and expected flight path (e.g., route conformance monitoring). Navigation communication services may require use of protected navigation frequencies for delivery of this information in certain cases.

Operational authorization. Operational authorization describes the process that an operator and certification authority use to obtain the authorization to use the aircraft data communications system and applications in operations in accordance with operational requirements (e.g., 14 CFR parts 91 through 139 if the certification authority is the Flight Standards Service of the FAA).

Operational environment. The operational environment consists of the air/ground subnetwork, the ground data communications system, the ground applications, and the operational aspects.

APPENDIX 2. DEFINITIONS AND ACRONYMS (Continued)

Performance. Performance describes the characteristics of the data communications system and applications associated with the functionality and capabilities of the data communications system or application, regardless of its availability and integrity. For example, message length, time to process a data communications message, memory capacity, and operational features are measures of performance. This AC uses performance in the context of a MOPS.

Safety requirements. Safety requirements are derived from the safety assessment and allocated to the aircraft systems or the operational environment.

Surveillance. Surveillance applications include the delivery of position and intent data (e.g., position waypoint passage and next waypoint) to permit ATS and other aircraft to monitor for safe and efficient separation. Surveillance applications include air-ground transmissions and air-air transmissions intended to supplement or eliminate the need for ground-based surveillance. Surveillance applications include automatic dependent surveillance (ADS).

APPENDIX 2. DEFINITIONS AND ACRONYMS (Continued)

2. Acronyms. The following acronyms are used in this AC.

Acronym	Description
AAC	Aeronautical administrative control
AC	Advisory circular
ACARS	Aircraft communications addressing and reporting system
ACO	Aircraft certification office
ADLP	Aeronautical data link processor
ADS	Automatic dependent surveillance
AEEC	Airlines Electronic Engineering Committee
AFN	ATS facilities notification
AMSS	Aeronautical mobile satellite service
AOC	Aircraft operational control
APC	Aeronautical public correspondence
ARAC	Administrator's Regulatory Advisory Committee
A/RFM	Airplane/rotorcraft flight manual
ARINC	Aeronautical Radio, Inc.
ARP	Aerospace recommended practice
ATA	Air Transport Association of America
ATC	Air traffic control
ATCRBS	Air traffic control radar beacon system
ATIS	Automatic terminal information service
ATM	Air traffic management
ATN	Aeronautical telecommunication network
ATS	Air traffic services
AVPAC	Aviation VHF packet communications
C/SOIT	Communications/Surveillance Operational Implementation Team
CFR	Code of Federal Regulations
CLNP	Connectionless network protocol
CLTP	Connectionless transport protocol
CMA	Context management
CNS	Communications, navigation, and surveillance
COTP	Connection oriented transport protocol
CPDLC	Controller Pilot Data Link Communications
CRC	Cyclic redundancy check
CVR	Cockpit voice recorder

APPENDIX 2. DEFINITIONS AND ACRONYMS (Continued)

Acronym	Description
DER	Designated engineering representative
DGPS	Differential global positioning system
ES-IS	End system-intermediate system
EUROCAE	European Civil Organization for Aeronautics
FAA	Federal Aviation Administration
FANS	Future air navigation system
FCAA	Foreign civil air authority
FDR	Flight data recorder
FIS	Flight information services
FMEA	Failure modes and effects analysis
FMS	Flight management system
HF	High frequency
HFDL	HF data link
ICAO	International Civil Aviation Organization
IDRP	Inter-domain routing protocol
ISO	International Organization for Standardization
ITU	International Telecommunication Union
JAA	Joint Aviation Authority
JAR	Joint airworthiness requirements
Mode S	Mode select
MOPS	Minimum operational performance standard
NAS	National airspace system
PDC	Pre-departure clearance
RTCA	RTCA, Inc.
SAE	Society of Automotive Engineers, Inc.
SARPS	Standards and recommended practices
SIRT	Systems Integration Requirements Task Group
TOC	Transfer of communications
TSO	Technical standard order
TWDL	Two-way data link
UNABLE	Unable to comply
VDL	VHF digital link
VHF	Very high frequency
WILCO	Will comply

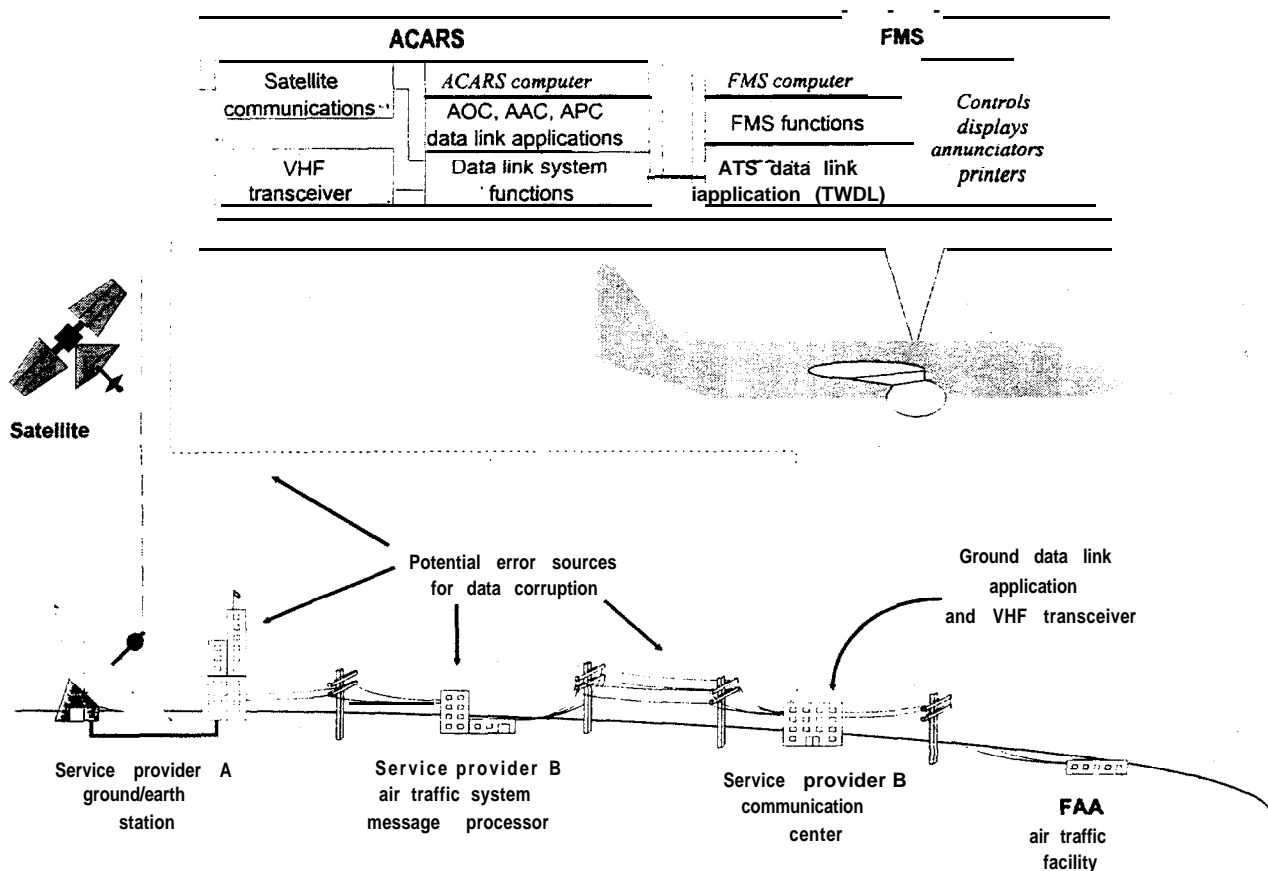
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APPENDIX 3. EXAMPLE OF A PARTIAL SAFETY ASSESSMENT

This appendix provides an example of a partial safety assessment on an ATS data communications application to assist in understanding the safety assessment process and the types of assumptions that are made to substantiate the results of the safety assessment. The safety assessment interacts with the system development process to evaluate different system architectures and designs and the effects of failures, design errors, and environmental conditions on the aircraft. For data communications systems and applications, the safety assessment may choose one particular architecture and design over another to minimize the effects of data communications system failures that are external to the aircraft. However, where assumptions are necessary, they are captured as safety and interoperability requirements (See paragraphs 1(f) and 1(g) of this appendix).

1. Introduction. One of the objectives for applying data communications technology is to provide digital communications between ground computers and aircraft computers, such as the flight management system (FMS), to minimize procedural and human errors in the delivery of ATM information from the air traffic controller to the flightcrew. To meet this objective, however, the data communications system and applications need to be of sufficient integrity. The aviation community has accepted safety assessments and design assurance techniques to ensure that adequate levels of integrity are achieved.

Figure 3-1. EXAMPLE OF DATA COMMUNICATIONS APPLICATIONS



APPENDIX 3. *EXAMPLE OF 4 PARTIAL SAFETY ASSESSMENT* (Continued)

a. Identification of aircraft level function and description of system. Figure 3-1 provides an example of an implementation of a TWDL data communications application intended for use in oceanic and remote airspace by the flightcrew to obtain changes from an air traffic controller to the flight plan filed prior to departure. The TWDL application uses the message set contained in Appendix A of RTCA DO-219 and the existing ACARS data communications system, which uses the VHF and satellite subnetworks. Service provider A operates the satellite subnetwork and service provider B operates the VHF air/ground subnetwork, the ground data communications system, and the ground TWDL application. Service provider B has an existing ground-ground communication network with the FAA ATC center.

b. Aircraft systems. The aircraft TWDL application shares the computer resources of the aircraft flight management system (FMS) with other FMS functions and uses the aircraft ACARS data communications system to interface with the satellite and VHF subnetworks. The TWDL application uses existing controls, displays, annunciators, and printers to provide information to the flightcrew.

c. Failure condition classification. The partial safety assessment considers the effects of an undetected error in the "altitude" variable in TWDL messages (as defined in RTCA DO-219) that the air traffic controller uplinks to the flightcrew. An undetected error in the uplink "altitude" variable has "major" effects on the aircraft when the "altitude" variable is used in an altitude change clearance to alter the filed flight plan. This failure condition is classified as "major" according to the failure condition categories defined in AC 25.1309-1A. The narrow spacing between altitude levels in oceanic and remote airspace does not allow time for correction of undetected errors by the ATC controller.

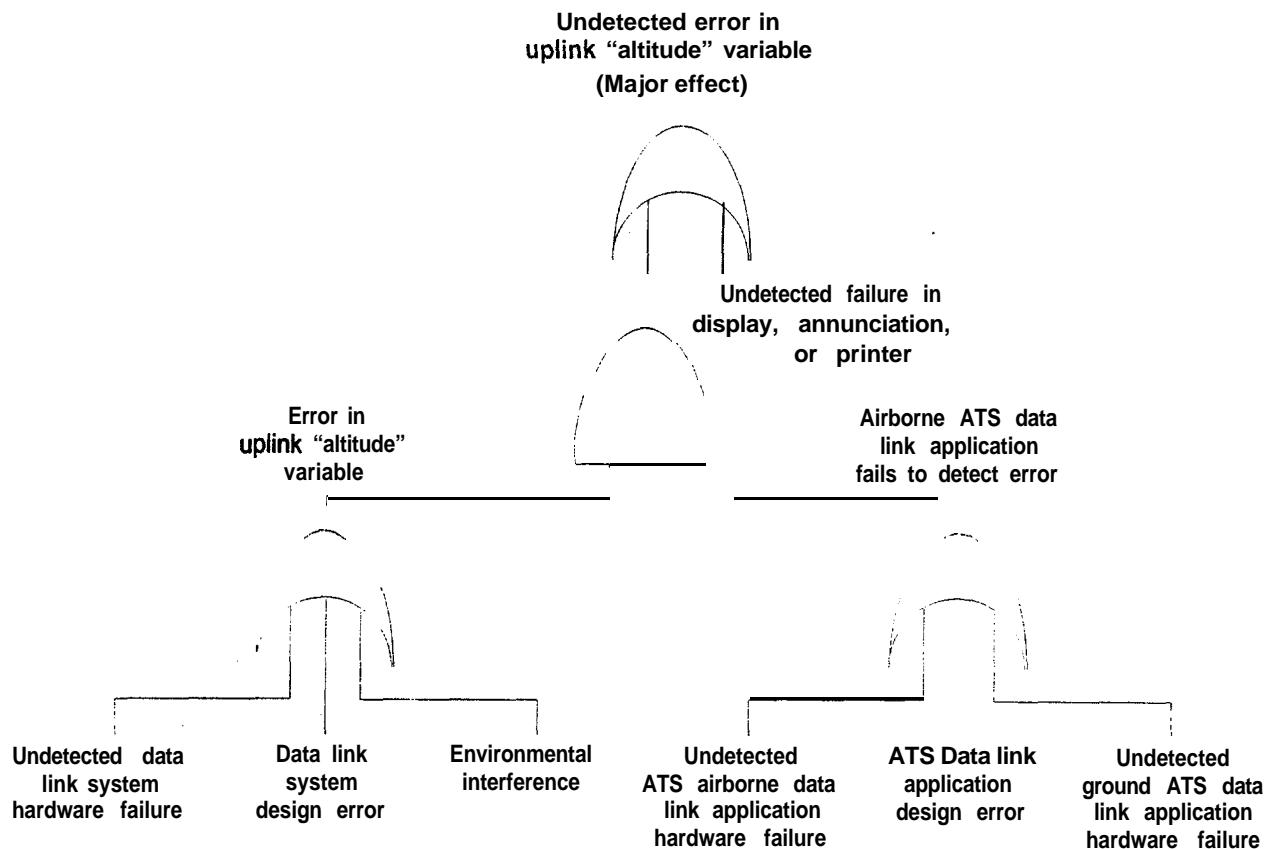
d. Fault Tree Analysis. Figure 3-2 provides a top level fault tree of the failure condition under consideration. The fault tree indicates potential hardware and software design errors, hardware failures, and environmental conditions that can cause or contribute to the failure condition. A common mode analysis shows that the inputs to the AND gate in the fault tree are independent, that is, both inputs to the AND gate are shown not to fail under the same condition. To show independence a 16 bit CRC is implemented in the FMS computer and the end system that hosts the ground TWDL application.

e. Design assurance. The aircraft TWDL application is integrated in the FMS with other FMS functions. A failure modes and effects analysis (FMEA) is conducted on the FMS hardware to show that the FMS system architecture and design adequately protect against undetected hardware failures contributing to the failure condition under consideration. The software for the TWDL application, the 16 bit CRC, and the controls, displays, and annunciators are developed to Level C, in accordance with RTCA DO-178B, to adequately protect against design errors. The analysis assumes that the end system that hosts the ground TWDL application, the 16 bit CRC, and controller interface provides an adequate level of design assurance.

f. Safety requirements allocated to aircraft systems. The following requirements have been identified for the aircraft data communications system and TWDL application:

(1) A 16 bit CRC shall be implemented in FMS computer.

(2) The software for the FMS computer shall be developed to Level C, in accordance with RTCA DO-178B.

APPENDIX 3. EXAMPLE OF A PARTIAL SAFETY ASSESSMENT (Continued)**Figure 3-2. TOP-LEVEL FAULT TREE FOR TWDL FAILURE CONDITION**

(3) The software for the aircraft human/machine interface (i.e., controls, displays, and annunciators) shall be developed to Level C, in accordance with RTCA DO- 178B.

(4) A primary communication system that meets current operating rules is required. The data communications system and applications supplement the primary communication system.

g. Safety requirements allocated to the ground end system. The following safety requirements have been identified for the end system that hosts the ground TWDL data communications application:

(1) A 16 bit CRC is implemented in the end system that hosts the ground TWDL application.

(2) The organization responsible for commissioning end system should adequately ensure that the safety requirements are implemented.

h. Evaluation of aircraft systems implementation. The safety assessment relies on design assurance activities and determines that the implementation of aircraft systems satisfies the requirements identified

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Appendix 4

APPENDIX 4. FORM TO SUBMIT SUGGESTIONS FOR IMPROVEMENT

Use this form or create your own to submit comments for improving future releases of advisory material pertaining to design approval of data communications systems and applications.

Suggestion for Improvement	
Send To: FAA, Aircraft Certification Service Aircraft Engineering Division (AIR-1 30) 800 Independence Avenue Washington, D.C.	Date:
Name:	
Voice:	Address
Fax:	
Internet:	
Reference sections:	
Rationale (Describe the reason for the change)	
Proposed change (Attach marked-up text or proposed rewrite)	
Please provide any general comments for improvement of this AC	

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